Neurally Adjusted Ventilatory Assist: NAVA for Neonates

Robert L. Chatburn, MHHS, RRT-NPS, FAARC
Research Manager – Respiratory Institute
Cleveland Clinic
Professor – Department of Medicine
Lerner College of Medicine of Case Western Reserve University
Disclosure

• I have affiliations with, special interests, or have conducted business with the following companies that in context with this presentation might possibly constitute a real or perceived conflict of interest: :
  – Breathe Technologies
  – CareFusion
  – Covidien
  – Dräger
  – Hamilton
  – IngMar
  – Newport
Overview

• What is NAVA?
• How does it compare to other modes?
• How does it serve the patient’s needs?
What is NAVA?

• Neurally Adjusted Ventilatory Assist
  — Inspiratory pressure is controlled by the diaphragmatic EMG, called the Edi signal
    ➢ *Edi is measured using a naso-gastiric catheter*
  — Ventilatory assistance is proportional to patient inspiratory effort

• Available only on Maquet Servo-i ventilator
## NAVA Compared to Other Modes

<table>
<thead>
<tr>
<th>Control Variable</th>
<th>Breath Sequence</th>
<th>Primary Targeting Scheme</th>
<th>Secondary Targeting Scheme</th>
<th>Example Mode Names</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volume Control</strong></td>
<td>CMV</td>
<td>Set-point</td>
<td>NA</td>
<td>Assist/Control</td>
</tr>
<tr>
<td></td>
<td>Dual</td>
<td>NA</td>
<td></td>
<td>CMV with Pressure Limited</td>
</tr>
<tr>
<td></td>
<td>IMV</td>
<td>Set-point</td>
<td>Set-point</td>
<td>SIMV</td>
</tr>
<tr>
<td></td>
<td>Dual</td>
<td>Set-point</td>
<td></td>
<td>SIMV with Pressure Limited</td>
</tr>
<tr>
<td></td>
<td>Adaptive</td>
<td>Set-point</td>
<td></td>
<td>Mandatory Minute Ventilation</td>
</tr>
<tr>
<td><strong>Pressure Control</strong></td>
<td>CMV</td>
<td>Set-point</td>
<td>NA</td>
<td>Pressure Control</td>
</tr>
<tr>
<td></td>
<td>Adaptive</td>
<td>NA</td>
<td></td>
<td>CMV with AutoFlow</td>
</tr>
<tr>
<td></td>
<td>IMV</td>
<td>Set-point</td>
<td>Set-point</td>
<td>BiLevel</td>
</tr>
<tr>
<td></td>
<td>Dual</td>
<td>Set-point</td>
<td></td>
<td>Volume Assured Pressure Support</td>
</tr>
<tr>
<td></td>
<td>Adaptive</td>
<td>Adaptive</td>
<td></td>
<td>Volume Control Plus SIMV</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
<td>Optimal</td>
<td></td>
<td>Adaptive Support Ventilation</td>
</tr>
<tr>
<td></td>
<td>CSV</td>
<td>Set-point</td>
<td>NA</td>
<td>Pressure Support</td>
</tr>
<tr>
<td></td>
<td>Servo</td>
<td>NA</td>
<td></td>
<td>NAVA and Proportional Assist Ventilation</td>
</tr>
<tr>
<td></td>
<td>Adaptive</td>
<td>NA</td>
<td></td>
<td>Volume Support</td>
</tr>
<tr>
<td></td>
<td>Intelligent</td>
<td>NA</td>
<td></td>
<td>SmartCare</td>
</tr>
</tbody>
</table>

*Respir Care 2012;57(12):2138-2150*
How Does NAVA Serve Patient Needs?

• What are a patient’s needs in terms of goals of MV?
• How do we match needs to technical capability?
• How does NAVA serve the patient’s needs?
Goals of Ventilation

1. Promote safety (do no harm)
   - Provide adequate gas exchange
     - Optimize $V/Q$ relation
   - Protect the lung
     - Optimize $P/V$ relation

2. Promote patient comfort
   - Optimize $WOB_{vent}$ vs $WOB_{patient}$

3. Liberate as soon as possible
   - Optimize weaning experience
AIM Before You ACT

Assess Patient Needs

Identify Technical Capability

Match Technology to Patient Needs

Safety Comfort Liberation

Modes of Ventilation
AIM Before you ACT

• **ASSESS**
  – Patient needs (safety, comfort, liberation)

• **IDENTIFY**
  – Available technology (modes and their capabilities)

• **MATCH**
  – Technology to needs (most appropriate mode)

• **ACT**
  – APPLY (appropriate settings)
  – CONSIDERED (monitor patient reaction)
  – TECHNOLOGY (reassess appropriateness of mode)
Relate Goals to Ventilator Features

GOALS OF MECHANICAL VENTILATION

Objectives Serving Goals

Aims of Clinical Management

Capabilities of Ventilators

Features of Specific Modes

A Rational Framework for Selecting Modes of Ventilation.
Comfort – Technical Capabilities of Modes

• All breaths can be spontaneous
• Trigger/cycle based on chest/diaphragm movement
• Coordination of mandatory vs spontaneous breaths
• Automatic limitation of autoPEEP
• Unrestricted inspiratory flow
• Automatic adjustment of flow based on frequency
• Automatic adjustment of support to maintain specific breathing pattern
• Automatic adjustment of support to meet demand
## Comfort

<p>| Mode Name                                      | Mode Classification | All Breaths Spontaneous with Patient Effort | Trigger/cycle Based on Signal Representing Chest Wall/ Diaphragm Movement | Coordination of Mandatory and Spontaneous Breaths | Automatic Limitation of AutoPEEP | Unrestricted Inspiratory Flow | Automatic Adjustment of Flow Based on Frequency | Automatic Adjustment of Support to Maintain Specific Breathing Patterns | Automatic Adjustment of Support Proportional to Patient Demand | Comfort Capabilities |
|------------------------------------------------|---------------------|---------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------|---------------------------------|-------------------------------|--------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|-------------------|
| IntelliVent-ASV                                | PC-IMV&lt;sub&gt;OLA&lt;/sub&gt; | ✓                                           | ✓                                                                         | ✓                                              | ✓                               | ✓                             | ✓                              | ✓                                             | ✓                                             | 4                 |
| Adaptive Support Ventilation                    | PC-IMV&lt;sub&gt;OD&lt;/sub&gt; | ✓                                           | ✓                                                                         | ✓                                              | ✓                               | ✓                             | ✓                              | ✓                                             | ✓                                             | 4                 |
| <strong>Neurally Adjusted Ventilatory Support</strong>      | PC-CSV&lt;sub&gt;R&lt;/sub&gt;  | ✓                                           | ✓                                                                         | ✓                                              | ✓                               | ✓                             | ✓                              | ✓                                             | ✓                                             | 4                 |
| SmartCare/PS                                    | PC-CSV&lt;sub&gt;1&lt;/sub&gt;  | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 3                 |
| Automode (Pressure Regulated Volume Control to Volume Support) | PC-IMV&lt;sub&gt;AA&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 3                 |
| Automode (Volume Control to Volume Support)    | VC-IMV&lt;sub&gt;DA&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 3                 |
| Mandatory Minute Volume with Pressure Limited Ventilation | VC-IMV&lt;sub&gt;DA,S&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 3                 |
| Mandatory Rate Ventilation                      | PC-CSV&lt;sub&gt;A&lt;/sub&gt;  | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 3                 |
| Proportional Assist Ventilation                 | PC-CSV&lt;sub&gt;R&lt;/sub&gt;  | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 3                 |
| Adaptive Pressure Ventilation Synchronized Intermittent Mandatory Ventilation | PC-IMV&lt;sub&gt;AS&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Mandatory Minute Volume Ventilation            | VC-IMV&lt;sub&gt;AS&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Volume Support                                  | PC-CSV&lt;sub&gt;A&lt;/sub&gt;  | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Synchronized Intermittent Mandatory Ventilation (Volume Control Maquet Servo-i) | VC-IMV&lt;sub&gt;DB&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| High Frequency Oscillatory Ventilation          | PC-IMV&lt;sub&gt;S&lt;/sub&gt;  | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Volume Control Synchronized Intermittent Mandatory Ventilation (Adaptive Flow &amp; 1 time GE Healthcare Versamed iVent 201) | VC-IMV&lt;sub&gt;AS,S&lt;/sub&gt; | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Pressure Support                                | PC-CSV&lt;sub&gt;3&lt;/sub&gt;  | ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Airway Pressure Release Ventilation             | PC-IMV&lt;sub&gt;N,S&lt;/sub&gt;| ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |
| Pressure Control Synchronized Intermittent Mandatory Ventilation | PC-IMV&lt;sub&gt;S,B&lt;/sub&gt;| ✓                                           |                                                                          |                                                |                                                |                               | □                             |                                                |                                                | 2                 |</p>
<table>
<thead>
<tr>
<th>Pressure Regulated Volume Control</th>
<th>PC-CMV&lt;sub&gt;A&lt;/sub&gt;</th>
<th>✓</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>□</th>
<th></th>
<th></th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>IntelliVue-ASV</td>
<td>PC-IMV$_{OLO}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Adaptive Support Ventilation</td>
<td>PC-IMV$_{OLO}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Automode (Pressure Regulated Volume Control to Volume Support)</td>
<td>PC-IMV$_{A}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Automode (Volume Control to Volume Support)</td>
<td>VC-IMV$_{DA}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Mandatory Minute Volume with Pressure Limited Ventilation*</td>
<td>VC-IMV$_{DA}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Adaptive Pressure Ventilation Synchronized Intermittent Mandatory Ventilation</td>
<td>PC-IMV$_{AS}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Mandatory Minute Volume Ventilation</td>
<td>VC-IMV$_{AS}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Pressure Regulated Volume Control</td>
<td>PC-CMV$_{A}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>SmartCare/PS</td>
<td>PC-CSV$_{1}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Volume Support</td>
<td>PC-CSV$_{A}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mandatory Rate Ventilation</td>
<td>PC-CSV$_{A}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Synchronized Intermittent Mandatory Ventilation (Volume Control Maquet Servo-I)</td>
<td>VC-IMV$_{DS}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>High Frequency Oscillatory Ventilation</td>
<td>PC-IMV$_{S}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Volume Control Synchronized Intermittent Mandatory Ventilation (Adaptive Flow &amp; I time GE Healthcare/ Versamed iVent 201)</td>
<td>VC-IMV$_{AS}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Volume Control Synchronized Intermittent Mandatory Ventilation</td>
<td>VC-IMV$_{S}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Continuous Mandatory Ventilation with Pressure Limited*</td>
<td>VC-CMV$_{D}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Volume Control Assist/Control</td>
<td>PC-CSV$_{R}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Neuraly Adjusted Ventilatory Support</td>
<td>PC-CSV$_{R}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Proportional Assist Ventilation</td>
<td>PC-CSV$_{R}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pressure Support</td>
<td>PC-CSV$_{S}$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Liberation

<table>
<thead>
<tr>
<th>Mode Name</th>
<th>Mode Classification</th>
<th>Ventilator Initiated Weaning of Support</th>
<th>Ventilator Recommends Liberation</th>
<th>Automatic Reduction of Support in Response to Increased Patient Effort</th>
<th>Liberation Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartCare/PS</td>
<td>PC-CSV₁</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>3</td>
</tr>
<tr>
<td>IntelliVent-ASV</td>
<td>PC-IMV₀,₀</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Adaptive Support Ventilation</td>
<td>PC-IMV₀,₀</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Automode (Pressure Regulated Volume Control to Volume Support)</td>
<td>PC-IMV₁,₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Automode (Volume Control to Volume Support)</td>
<td>VC-IMV₁,₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Mandatory Minute Volume with Pressure Limited Ventilation*</td>
<td>VC-IMV₁,₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Adaptive Pressure Ventilation Synchronized Intermittent Mandatory Ventilation</td>
<td>PC-IMV₁,₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Mandatory Minute Volume Ventilation Volume Support</td>
<td>PC-IMV₁,₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Regulated Volume Control</td>
<td>PC-CSV₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>1</td>
</tr>
<tr>
<td>Neurally Adjusted Ventilatory Support</td>
<td>PC-CSV₁</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>0</td>
</tr>
<tr>
<td>Mandatory Rate Ventilation</td>
<td>PC-CSV₁</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Synchronized Intermittent Mandatory Ventilation (Volume Control) (Maquet Servo-i)</td>
<td>VC-IMV₁,₁</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Proportional Assist Ventilation</td>
<td>PC-CSV₁</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>High Frequency Oscillatory Ventilation</td>
<td>PC-IMV₁</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

How Does NAVA Work?

• Measuring diaphragmatic EMG (the Edi signal)
• Neuroventilatory coupling
• Patient-ventilator interactions
• Literature review
The Edi Catheter

Edi Catheter Features

Inter-Electrode Distance
Connect the Catheter to the Cable
Neurally Adjusted Ventilatory Assist

Respiratory Inputs Affecting NAVA

Origin of Edi Signal

Facts About the Edi Signal

• Edi represents diaphragmatic electrical activity

• Edi signal is measured in microvolts (µV)
  — $Edi_{\text{peak}}$ 11 ± 5 µV
  — $Edi_{\text{min}}$ 3 ± 2 µV

• Increased neural input to diaphragm from the brain
  — Increased motor unit firing rate
  — Increased motor unit recruitment
  — Increased Edi amplitude
  — Increased inspiratory effort (Pmus)
Ventilator Display
Edi Signal Nomenclature

Pediatric Research 2011;70(6)607-613
Infant vs Adult Edi Signals

more variability (phasic Edi)

variable baseline (tonic Edi)

Edi as a Monitoring Tool

• Increased Edi amplitude on inspiration (“phasic Edi”) indicates greater inspiratory effort

• Edi amplitude increases with
  — worsening respiratory status
  — reduced ventilator assist
  — reduced sedation
  — increased ventilatory demand (eg, exercise)
  — increased dead space
Edi as a Monitoring Tool

• **Neuro-mechanical efficiency**
  - $\text{Paw}/\text{Edi}$ during occlusion
  - inspiratory pressure normalized to neural inspiratory effort

• **Neuro-ventilatory efficiency**
  - $V_T/\text{Edi}$
  - inspiratory volume normalized to neural inspiratory effort

• **Tonic Edi may indicate response to lung derecruitment**
  - might be used to set optimum PEEP
Tonic Edi vs PEEP

Edi as a Monitoring Tool

• Edi is “gold standard” for determining asynchrony

• Trigger asynchronies
  — premature trigger (“auto-trigger”)
  — delayed trigger
  — missed trigger efforts

• Inspiratory pressure asynchrony
  — assist too high/low

• Cycling asynchrony
  — premature cycling
  — delayed cycling
Examples of Asynchronies

Examples of Asynchronies

Examples of Asynchronies

- Pressure asynchrony
- Under-assist premature cycling
- Trigger delay

Examples of Asynchronies

Examples of Asynchronies

NAVA  |  PCV  |  PSV

**Neural Inspiratory Time**

- **Good Synchrony**
  - NAVA: Normal cycle with good synchrony.
  - PCV: Normal cycle with good synchrony.
  - PSV: Normal cycle with good synchrony.

- **Bad Synchrony**
  - NAVA: Delayed cycling due to trigger delay.
  - PCV: Delayed cycling due to trigger delay.
  - PSV: Delayed cycling due to trigger delay.

**Diagrams**

- **Pvent (cm H2O)**
- **Edi (µV)**

**Key Points**

- **Good Synchrony**:
  - Pvent and Edi align normally.

- **Bad Synchrony**:
  - Pvent and Edi do not align normally due to trigger delay.
  - Delayed cycling occurs.

**Legend**

- **Green Arrow**: Good synchrony.
- **Red Arrow**: Bad synchrony with trigger delay.
- **Delayed Cycling**: Indicated by 2 and 3 markers.
How Does Edi Control the Ventilator?

Diaphragm

Ventilator

Transrespiratory pressure

How Does Edi Control the Ventilator?

How Does Edi Control the Ventilator?

How Does Edi Control the Ventilator?

How Does Edi Control the Ventilator?

\[
\text{inspiratory pressure} = \text{NAVA level} \times \text{Edi}
\]

\[
\text{cm } H_2O \text{ above PEEP} \quad \text{cm } H_2O/\mu V \quad \text{above Edi}_{\text{min}}
\]

NAVA Unloads Spontaneous Breaths

Volume Control?  
Pressure Control?  
NAVA?
NAVA Is Not Affected by Leaks

<table>
<thead>
<tr>
<th>Leak (L/min)</th>
<th>NIV-PSV</th>
<th>NIV-NAVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
</tr>
<tr>
<td>3</td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
</tr>
<tr>
<td>6</td>
<td><img src="image5" alt="Graph" /></td>
<td><img src="image6" alt="Graph" /></td>
</tr>
<tr>
<td>9</td>
<td><img src="image7" alt="Graph" /></td>
<td><img src="image8" alt="Graph" /></td>
</tr>
</tbody>
</table>
How Do You
Set the NAVA Level?
Response to Increasing Edi

• Phase I
  – at low NAVA level, Edi is highest amplitude
  – increasing NAVA increases inspiratory pressure

• Phase II
  – increasing NAVA level decreases Edi
  – inspiratory pressure constant in “comfort zone”
  – assist levels adequate to unload ventilatory muscles

• Phase III
  – increasing NAVA still decreases Edi
  – Edi not abolished so can still control ventilator
  – irregular breathing pattern
Response to Increasing NAVA Level

Response to Increasing NAVA Level

Weaning NAVA

• Lower NAVA level in increments of 0.5 while following the Edi peak
  — If the Edi peak increases significantly, then the patient may not be ready for weaning

• Follow the peak inspiratory pressure trend
  — When at sufficiently low levels, consider extubation

Stein H, Bringing NAVA to the NICU, Advance for RC & Sleep Medicine, 2010
The Evidence for NAVA in Neonates
Advantages of NAVA in Neonates

• Improves synchrony, even with large leaks
  — Pediatr Crit Care Med 2010;11:7-11
  — Intensive Care Med 2011;37:1826
  — Pediatr Pulmonol 2012;47(1)76-83

• Decreased PIP, variable respiratory rate
  — Crit Care Med 2010;11:253-7
  — Neonatology Today 2010;5:1-4
  — Pediatr 2011;11:92
  — J Pediatr 2012;160:786-9
Advantages of NAVA in Neonates

• Improved or unchanged blood gas results
  — Pediatr Crit Care Med 2010;11:7-11
  — Crit Care Med 2010;11:253-7
  — Neonatology Today 2010;5:1-4
  — Pediatr 2011;11:92
  — Pediatr Pulmonol 2012;47(1)76-83
  — J Pediatr 2012;160:786-9

• No change in intraventricular hemorrhage, pneumothorax or nectorizing enterocolitis
  — J Pediatr 2012;160:786-9
Clinical Findings of NAVA in Neonates

• Tidal volume 5.3 – 8.7 mL/kg
  — Considered a “lung protective” mode

• Respiratory rate 35-59 breaths/min
  — Crit Care Med 2010;11:253-7
  — Pediatr Crit Care Med 2010;11:7-11
  — Pediatr 2011;11:92
  — Pediatr Pulmonol 2012;47(1)76-83
  — J Pediatr 2012;160:786-9
Clinical Findings of NAVA in Neonates

• Post-extubation Edi higher in infants who failed extubation (30 vs 11 µV)

• No differences in heart rate, systolic BP, CVP, PaO₂/FiO₂ or PaCO₂
  — Zhongguo Dang Dai Er Ke Za Zhi 2009;11:433-6

• Patients ready for extubation had higher Vₜ/Edi (25 vs 21 mL/ µV)
Better Synchrony with NAVA

• No missed trigger efforts compared to PCV, PSV (0% vs 4% vs 7%)

• Shorter trigger delays (93 vs 193 vs 135 ms)

• No premature cycling (0% vs 12% vs 21%)
Summary

• NAVA is a form of pressure control continuous spontaneous ventilation with a servo targeting scheme (PC-CSVr)
  — Servo control is based on diaphragmatic EMG called the Edi signal
  — Edi amplitude proportional to inspiratory effort
    ➢ *Phasic Edi increases as lung mechanics worsen*
  — Paw = NAVA Level x ΔEdi

• NAVA was designed to serve the goal of comfort
  — Optimizes patient-ventilator synchrony
    ➢ *trigger/cycle close to neural signal (leak independent)*
    ➢ *pressure delivery in proportion to inspiratory effort*
Summary

• Neonates have highly variable phasic Edi plus positive tonic Edi

• Monitoring Edi is the “gold standard” for identifying patient-ventilator asynchronies

• Patients have a bi-phasic response to increasing NAVA
  — first $V_T$ increases with NAVA
  — then $V_T$ remains relatively constant with increasing NAVA

• Wean NAVA by gradually decreasing NAVA level and watching to see that phasic Edi remains constant.
Summary

• Improves synchrony even with leaks (NIV)
  — trigger, inspiratory pressure, cycle
• Decreases peak inspiratory pressure
• Maintains lung protective tidal volumes
• May improve blood gases
• Not associated with adverse events
• Edi signal analysis may provide predictive indices for success of extubation
Assistance in Proportion to Effort